

The Mississippi Test Site:

Establishing Safe, Secure and Publicly Accepted CO₂ Storage in a Regionally Extensive, Deep Gulf Coast Saline Reservoir

Presented to:

U.S. Department of Energy

Presented by:

Richard Rhudy

Electric Power Research Institute

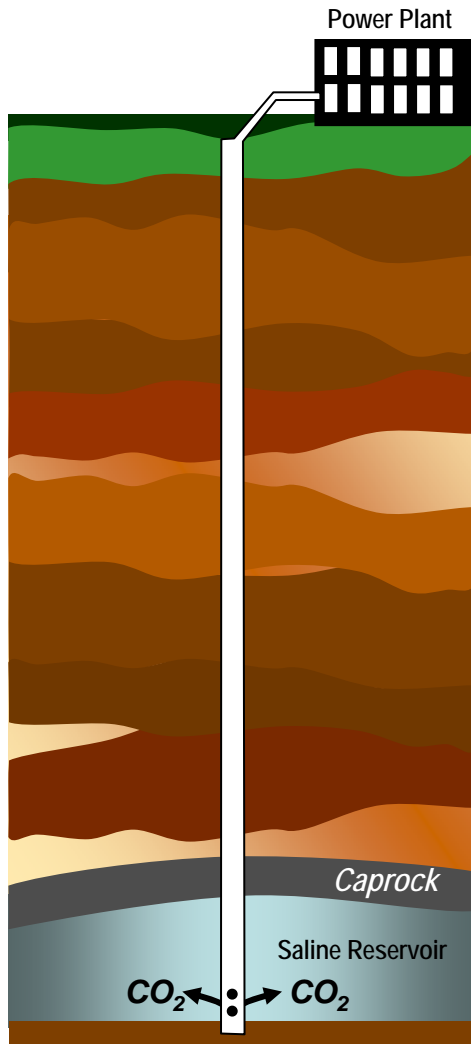
Richard Esposito

Southern Company Services

Pittsburgh, PA

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Mississippi Saline Reservoir CO₂ Injection Project

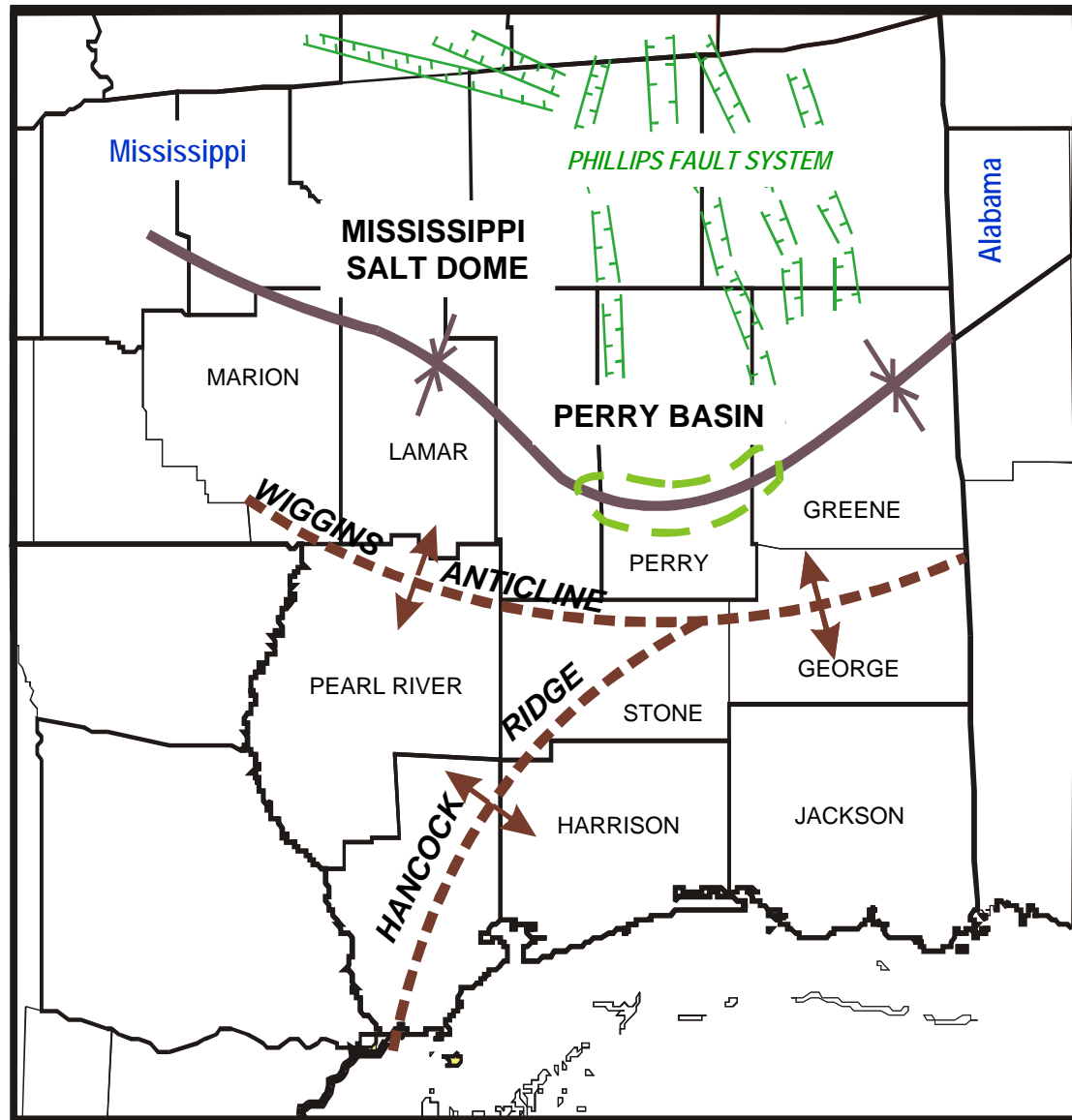


- **Purpose:** Locate and test suitable geological sequestration sites in proximity to large coal-fired power plants in the Southeast region
- **Initial Target:** Deep saline reservoirs along MS Gulf Coast with high potential CO₂ storage capacity
- **Objectives:**
 - Build geological and reservoir maps for test site
 - Conduct reservoir simulations to estimate injectivity, storage capacity, and long-term fate of injected CO₂
 - Address state/local regulatory and permitting issues
 - Foster public education and outreach
 - Inject 3,000 tons of CO₂
 - Conduct longer-term monitoring

Mississippi Test Site Evaluation

The site evaluation process is designed to assure selection of a safe, secure CO₂ storage site and formation:

- Competent, regionally extensive caprock and seal(s)
- Multiple shallower “safety zones”
- Updip structural confinement
- High CO₂ storage capacity with favorable reservoir properties
- Favorable hydrological system
- Protection of potable and low salinity water
- Mapping of older, abandoned wells



Saline Reservoir Units and Seals (SE Mississippi)

Potential CO₂ Storage Units

- Lower Tuscaloosa Massive Sand Unit (U. Cretaceous)
- Dantzler Formation (L. Cretaceous)

Confining Units (Seals):

- Marine Tuscaloosa
- Austin Formation (Fm.)
- Selma Chalk/Navarro Fm.
- Midway Shale

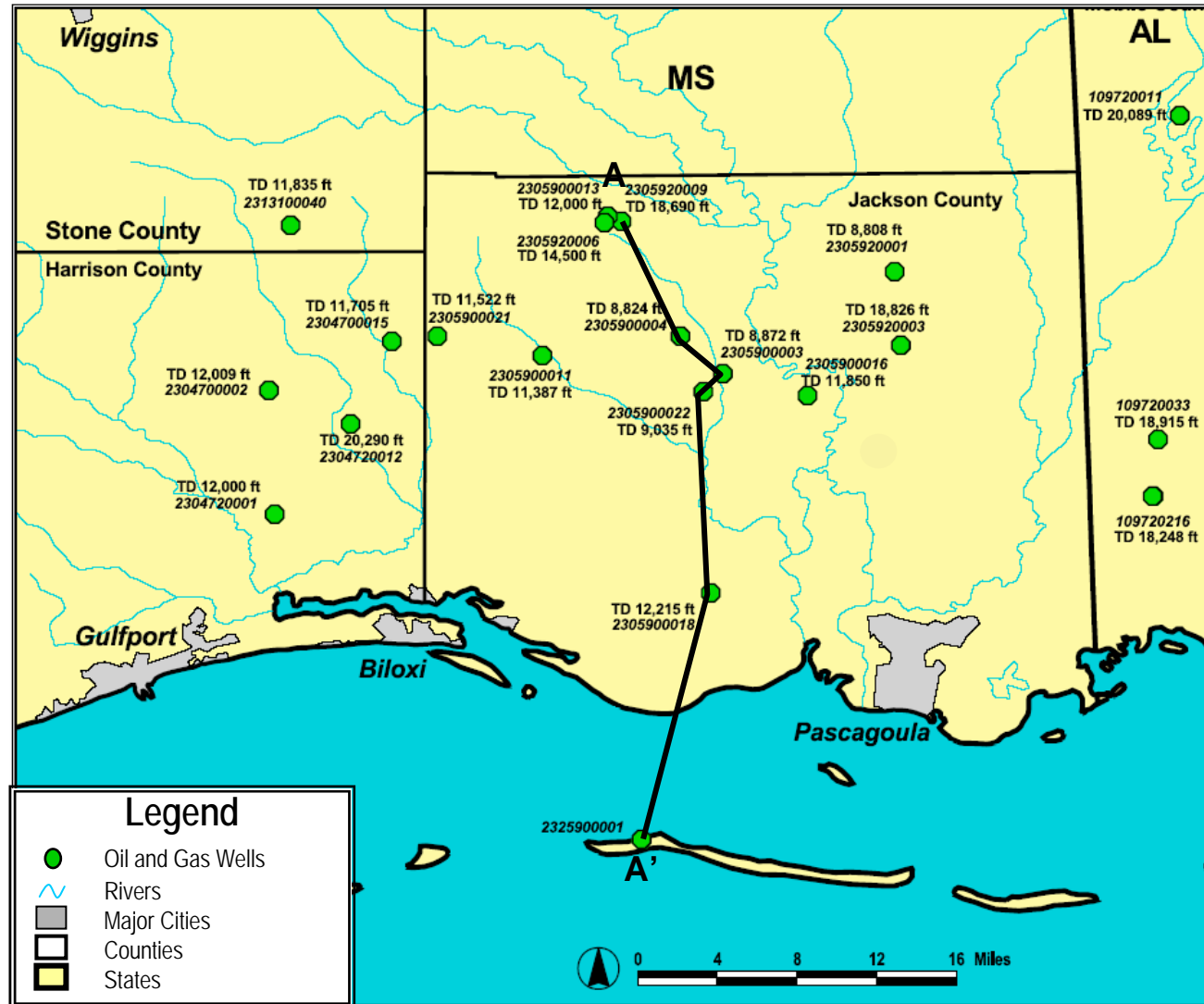
System	Series	Stratigraphic Unit	Sub-Units	Hydrology
Tertiary	Miocene	Misc. Miocene Units	Pascagoula Fm.	Freshwater Aquifers
			Hattiesburg Fm.	
			Catahoula Fm.	
	Oligocene	Vicksburg		Saline Reservoir
			Red Bluff Fm.	Minor confining unit
	Eocene	Jackson		Saline Reservoir
		Claiborne		Saline Reservoir
		Wilcox		Saline Reservoir
	Paleocene	Midway Shale		Confining unit (Seal)
Cretaceous	Upper	Selma Chalk	Navarro Fm.	Confining unit (Seal)
			Taylor Fm.	
		Eutaw	Austin Fm.	Confining unit (Seal)
			Eagle Ford Fm.	Saline Reservoir ← CO ₂
		Tuscaloosa Group	Upper Tusc.	Minor Reservoir
			Marine Tusc.	Confining unit (Seal)
			Lower Tusc.	Saline Reservoir ← CO ₂
		Washita Fredricksburg	Dantzler Fm.	Saline Reservoir ← CO ₂
			"Limestone Unit"	

Cross Section A-A' Location

A total of 24 wells - -
20 oil & gas plus 4
Class II wells - -
provided the essential
deep subsurface
information for the
Mississippi Gulf Coast
area.

The nearest deep
wells are about 5 to 10
miles away, limiting
available geologic
information for the
plant area.

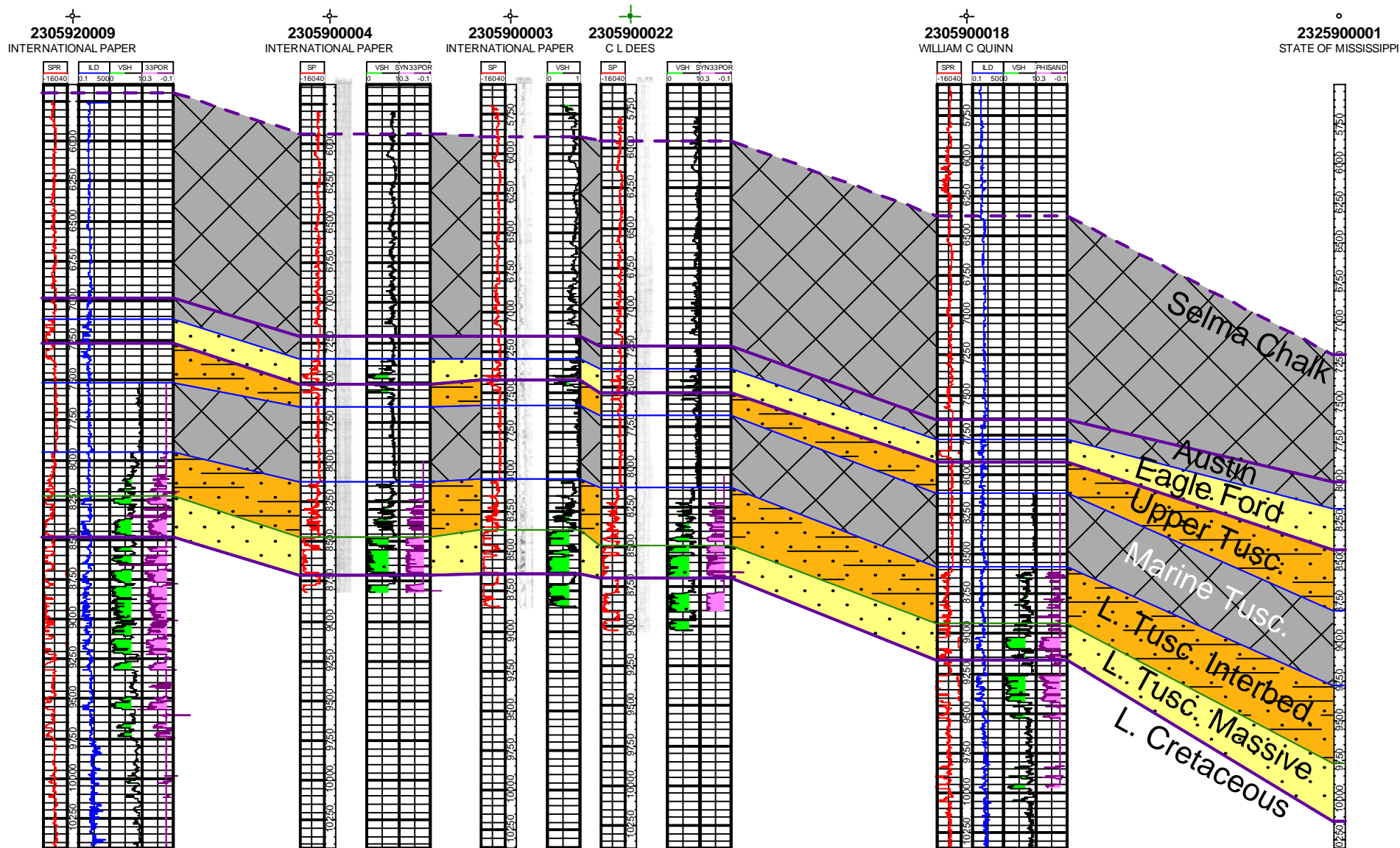
The primary North-
South cross section
contains 8 data wells.



A(N)

A-A' Structural Cross Section

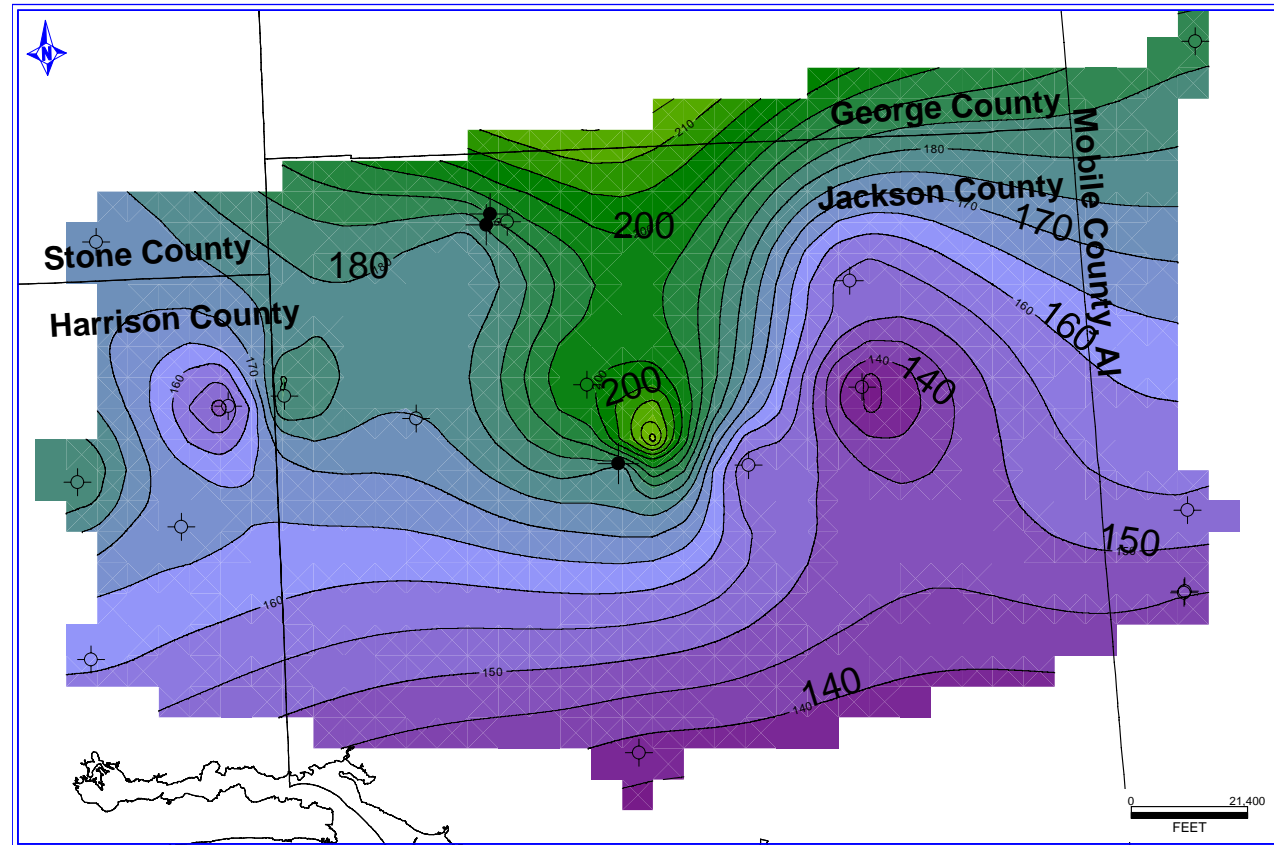
A'(S)



Net Sand Thickness Lower Tuscaloosa Massive Sand Unit

Reservoir mapping confirms that the Massive Sand Unit of the Lower Tuscaloosa Fm. contains a thick section of net sand in southern Mississippi.

Even thicker units of deeper L. Cretaceous-age sediments underlie the Tuscaloosa Formation, but still require more detailed mapping.



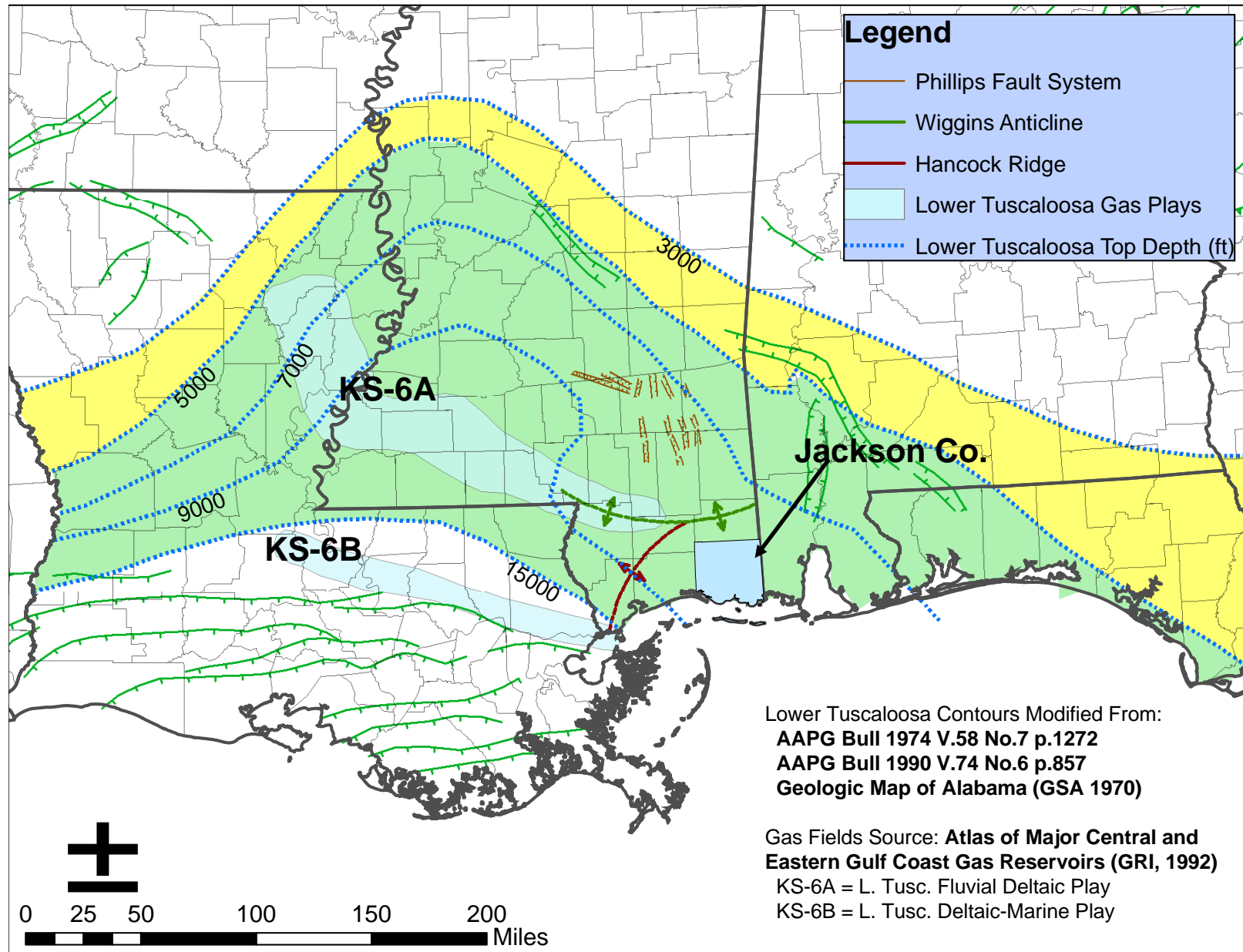
Tuscaloosa Saline Formation CO₂ Storage Capacity

The potential CO₂ storage capacity of the saline reservoirs in the site area is considerable:

- Using 20% porosity, 190 feet of net thickness and 700 mi² of mapped areal extent for Jackson County, MS, the Tuscaloosa Massive Sand Unit saline formation has 2 billion metric tons of total usable storage capacity.
- Adding the deeper and shallower sand units to the Tuscaloosa Massive Sand would increase the net thickness to 600 feet and raise the total usable storage capacity to 6 billion metric tons.

The Tuscaloosa Massive Sand and associated sand units underlie much of the central and eastern Gulf Coast, providing an extensive saline reservoir setting for CO₂ storage. Work is underway to more rigorously establish the storage volume and capacity for this larger region.

Regional Extent of the Lower Tuscaloosa Massive Sand Unit



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- This map displays the Biloxi and Pascagoula regions, highlighting elevation contours and political boundaries. The map includes a legend in the top right corner defining symbols for Rivers (blue wavy line), Cities (black dot), Counties (black outline), Township and Ranges (red outline), and States (yellow background). The map shows the Mississippi River (MS) and the Alabama River (AL) flowing through the area. Elevation contours are marked with dashed lines and labeled with values: 1600, 1800, 2000, 2200, 2400, 2600, 2800, and 3000. The map also shows the boundaries of Jackson County and Mobile County, and the states of Mississippi (MS) and Alabama (AL). The Biloxi and Pascagoula rivers are shown flowing into the Gulf of Mexico. A scale bar at the bottom indicates distances from 0 to 20 miles.

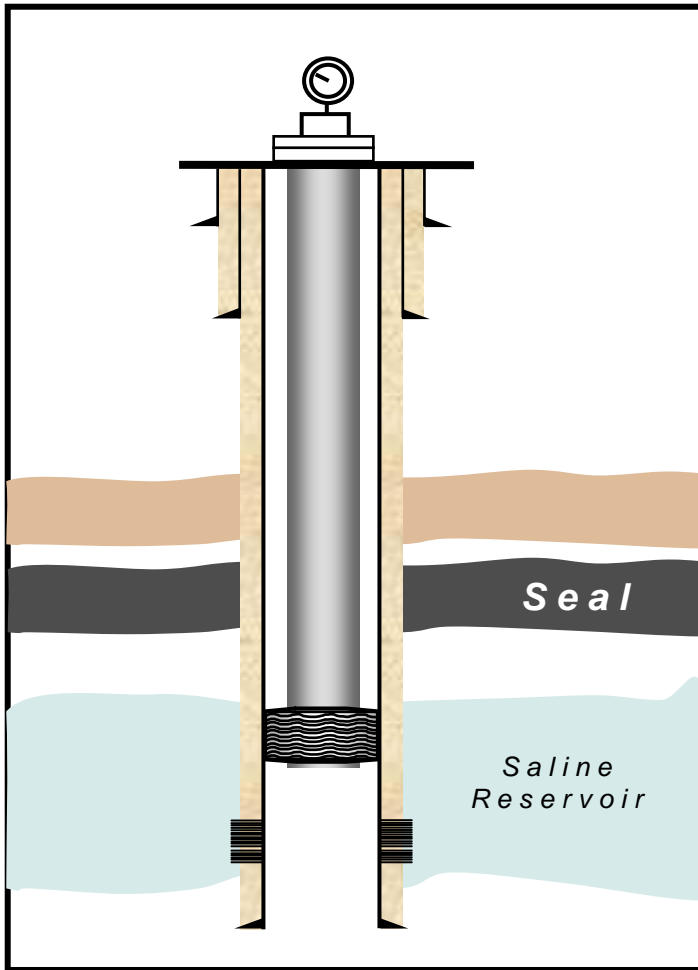
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Further Reservoir Characterization

The drilling of the observation and injection wells will allow for local data collection that will be used for geologic characterization and subsequent reservoir modeling input data.

Key Data:

- The taking of core from the caprock (seal) and proposed storage formation
 - Permeability, porosity and lithology
- Wireline geophysical logging
 - Depth, thickness and porosity
- Pressure transient testing
 - Permeability and completion efficiency
- Stress testing
 - Fracture gradient and injectivity



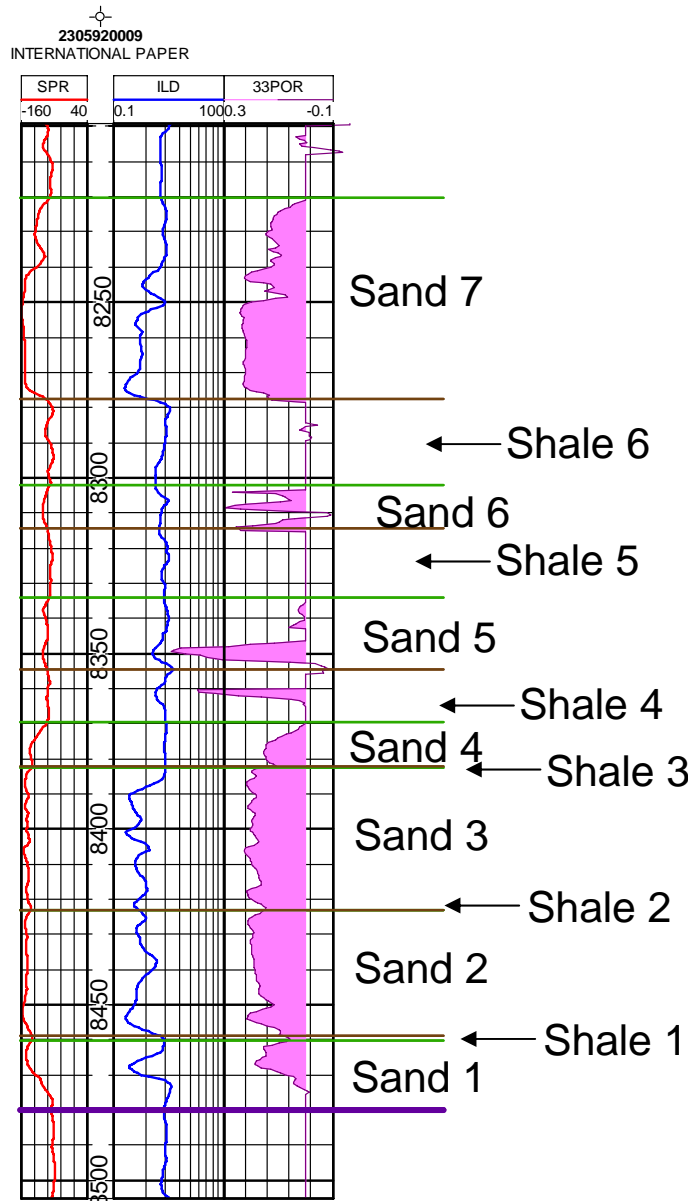
Reservoir Modeling of CO₂ Injection: Pilot Test

A series of reservoir simulations have been conducted to better understand the flow and storage of CO₂ in the Tuscaloosa Massive Sand Unit:

- The geologic and reservoir characterization work has provided the essential model input data
- The detailed log analysis has identified seven sand flow units and six internal shale barriers in the Massive Sand Unit

More detailed reservoir modeling will be conducted once new data are obtained from logging and testing the observation and CO₂ injection wells.

Massive Sand Unit Flow Units



Seven sand units and six shale layers were identified in the Massive Sand Unit.

These sand units will provide storage, while the shale layers will act as barriers or “baffles” to the flow of CO₂.

During the pilot test, 3,000 tons of CO₂ will be injected into the lower most sand unit (Sand 1) at a rate of 100 tons per day for 30 days.

Reservoir Modeling CO₂ Injection/Plume (vertical view)

30 days

A series of reservoir simulations will be conducted to model the movement and trapping of the CO₂ plume.

CO₂ Injection Point
(19 foot interval)

±250 ft.

5 years

Sand 7
Shale 6
Sand 6
Shale 5
Sand 5
Shale 4
Sand 4
Shale 3
Sand 3
Shale 2
Sand 2
Shale 1
Sand 1

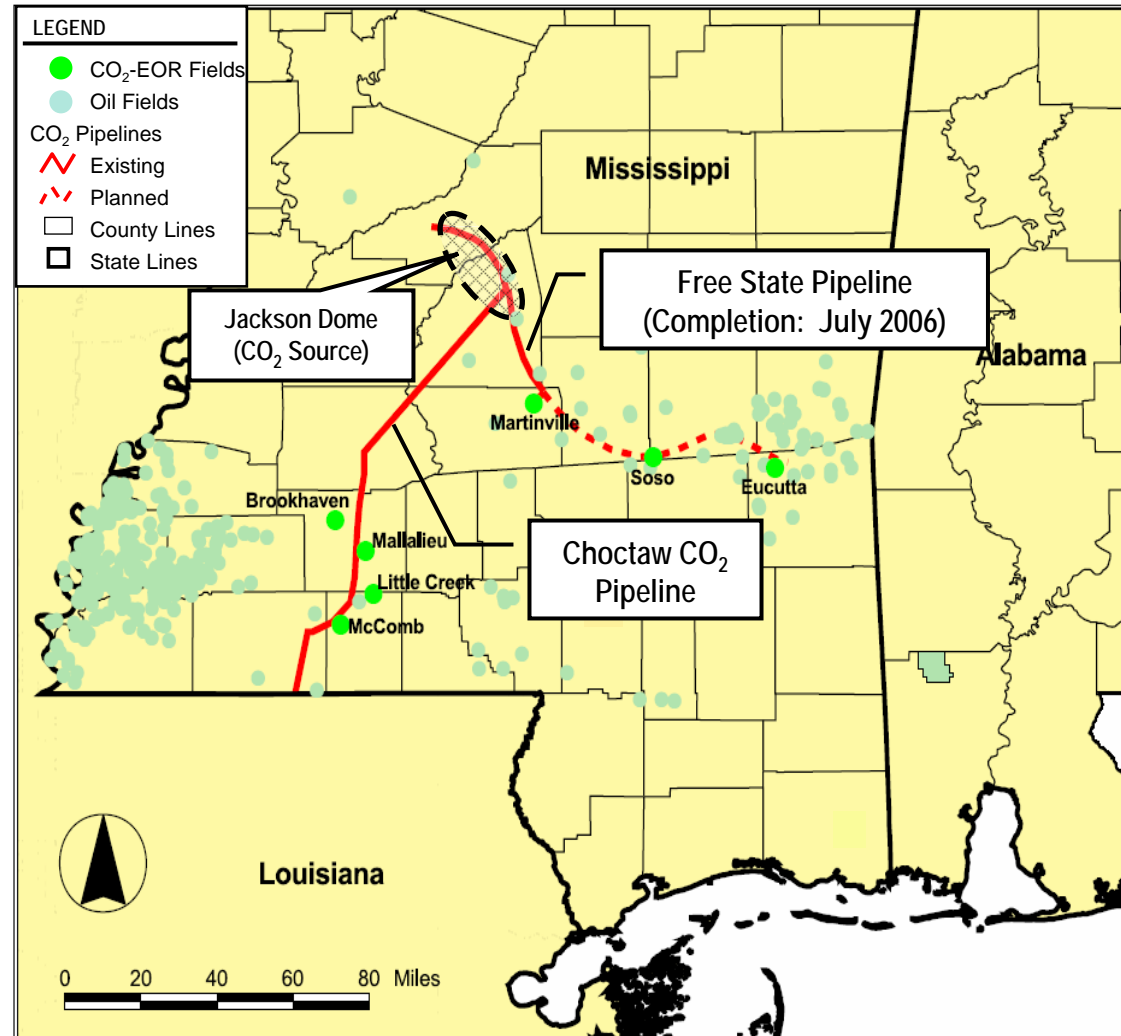
1 Mile

Gas Saturation, frac (Day 1,825)

0.00 0.10 0.20 0.30 0.40 0.50

Existing CO₂ Sources and Pipelines

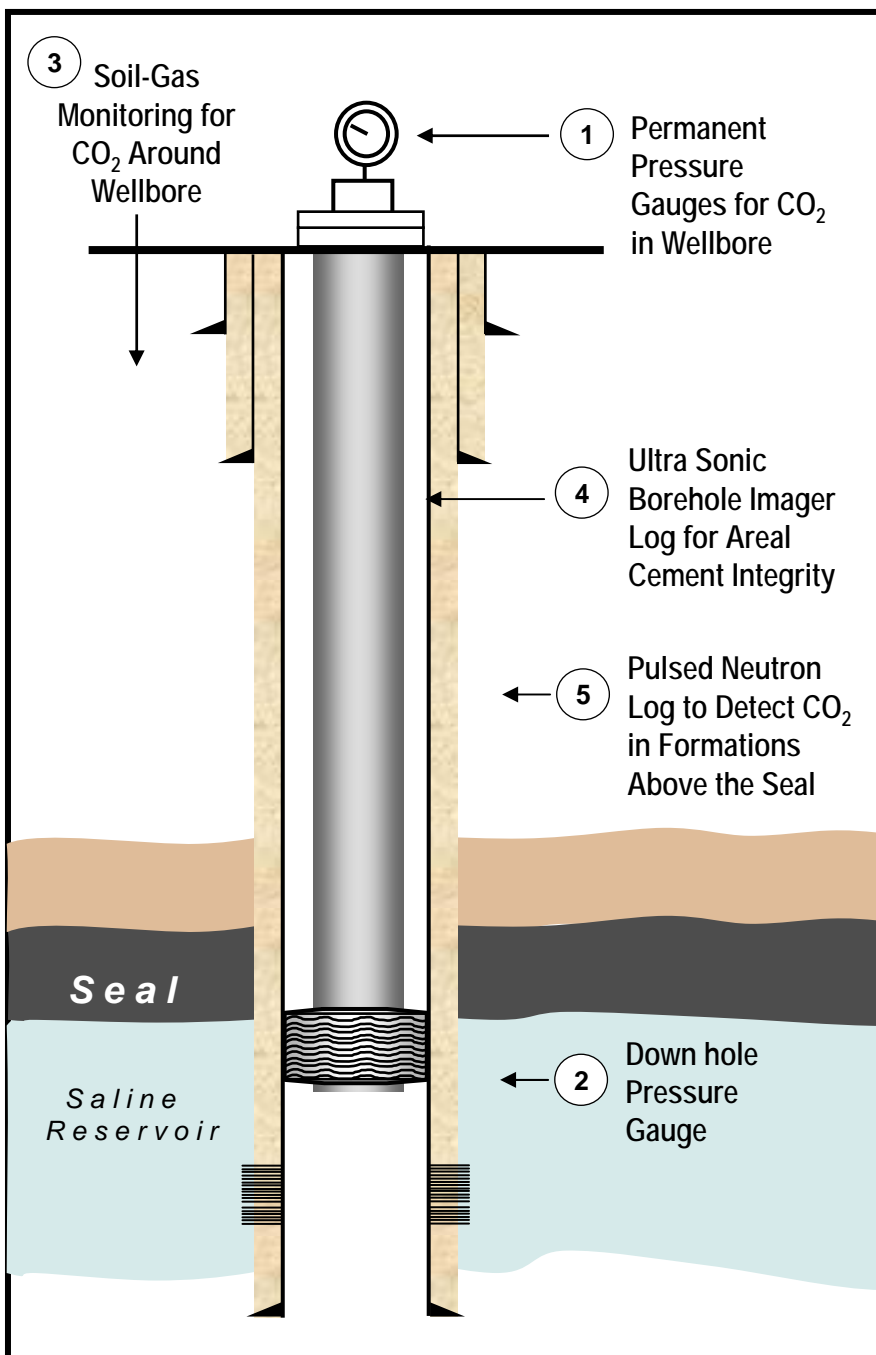
- Denbury Resources operates a CO₂ pipeline from Jackson Dome to oil fields in Mississippi.
- Denbury Resources will provide CO₂ at no cost to the Project.
- CO₂ is liquefied and transported by truck; then injected as a supercritical fluid.
- CO₂ injected during test (100 tons per day for 30 days) is small compared to existing CO₂ injection and transportation (52,000 tons per day) in the region.



Well Integrity and Pressure Monitoring

The project will include a series of MMV activities to assure well integrity:

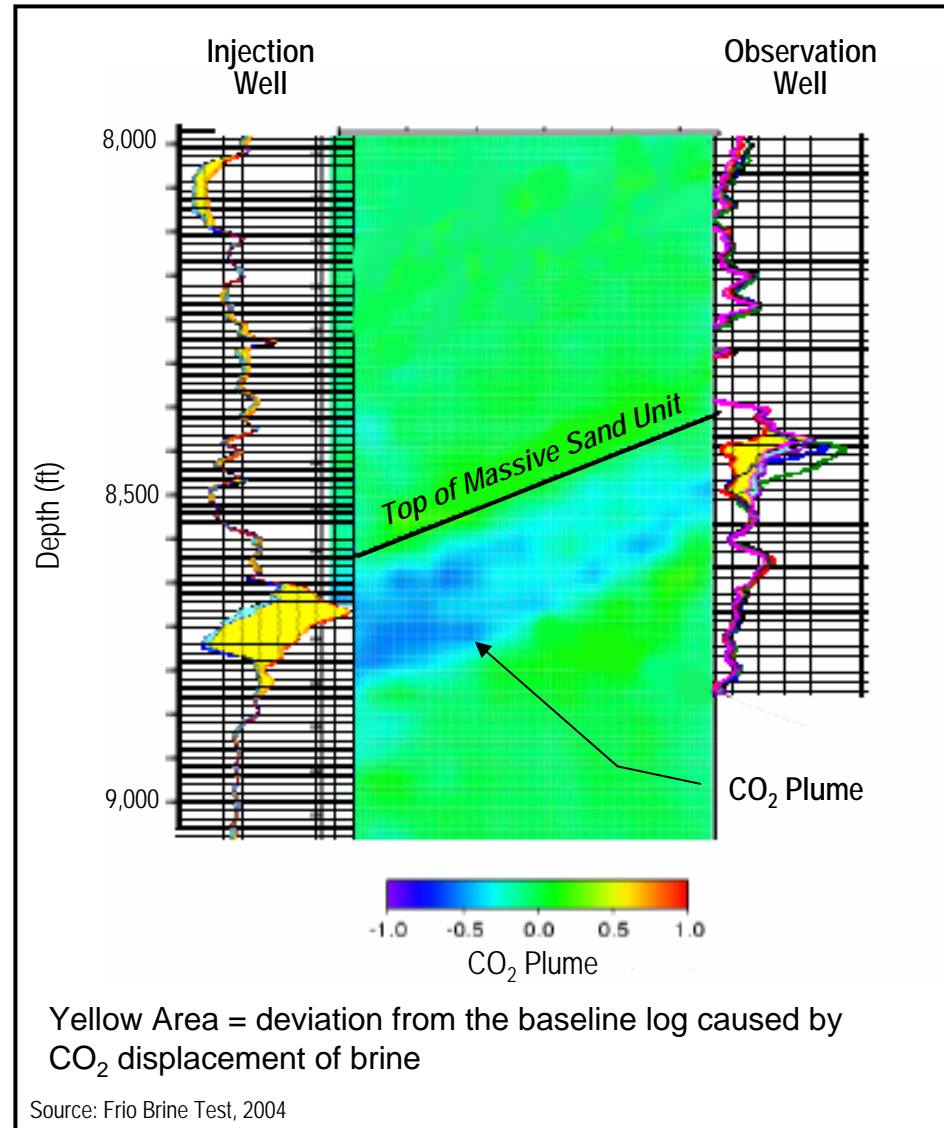
- To assure well integrity at the surface, we will: (1) install a pressure gauge on the wellhead to measure sustained casing pressure (CO₂ leakage in the well); (2) conduct continuous monitoring of annular and down hole pressure; and, (3) conduct near-surface soil gas measurements.
- To assure downhole well integrity, we will: (4) use an Ultra Sonic Borehole Imager (advanced version of the Cement Bond Log) both after cementing and after CO₂ injection; and, (5) run a series of RST Logs to detect CO₂ above the reservoir seal.



CO₂ Plume Monitoring

To monitor the flow and storage of CO₂ in the saline reservoir, we will use well logs, seismic and other tools:

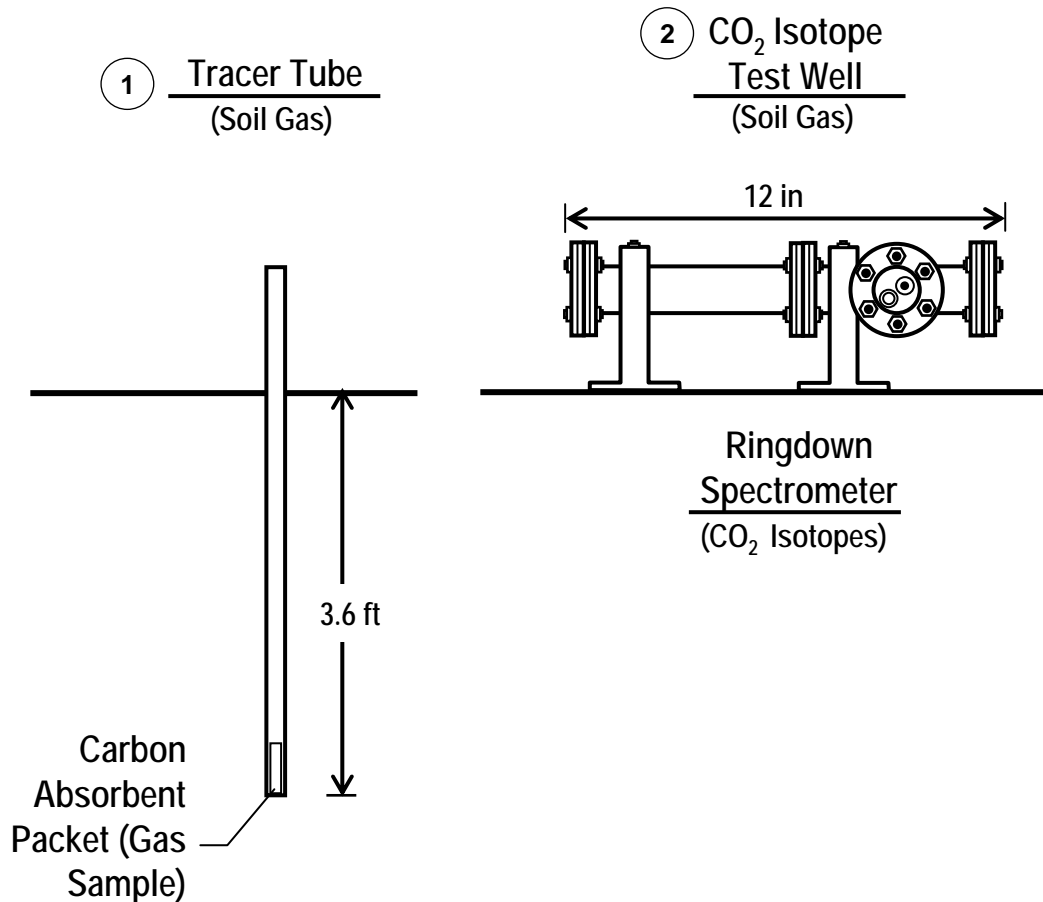
- For monitoring the areal profile of the CO₂ plume, we will use time-lapse Vertical Seismic Profiles (VSP) before CO₂ injection and about 1 month after CO₂ injection.
- For monitoring the vertical profile of the CO₂ plume, we will use: (1) a time lapse series of RST (Reservoir Saturation Tool) logs (in both wells) and (2) also use time-lapse VSP.



Near-Surface Monitoring

- **Soil Flux.** An automated real-time monitoring system will be used to determine surface soil CO₂ flux.
- **Tracer Injection with CO₂.** Tracers such as Perfluorocarbons (PFT's) or SF₆ will be added at the wellhead and used to tag and track injected CO₂. Capillary Absorption Tube Samplers (CATS) placed in shallow boreholes or surface sweep monitoring using SeeperTrace™ sample collection will be performed.
- **CO₂ Isotopes.** NETL & Mississippi State University (MSU) have developed on-site, real-time equipment that measures isotopic signatures. This portable “Cavity Ringdown Spectrometer” is planned for use during the project. Jackson Dome CO₂ will have a unique signature since it will likely be more enriched in ¹³C than anthropogenic or biogenic carbon.
- **Base-line Monitoring.** Monitoring will be performed before, during, and after injection CO₂ injection for all MMV protocols.

Near-Surface Monitoring



To detect any CO₂ seepage from the well, through the seal or other leakage points, we will use near-surface monitoring to: (1) detect tracers injected with the CO₂; and/or, (2) detect CO₂ isotopes unique to the injected CO₂.

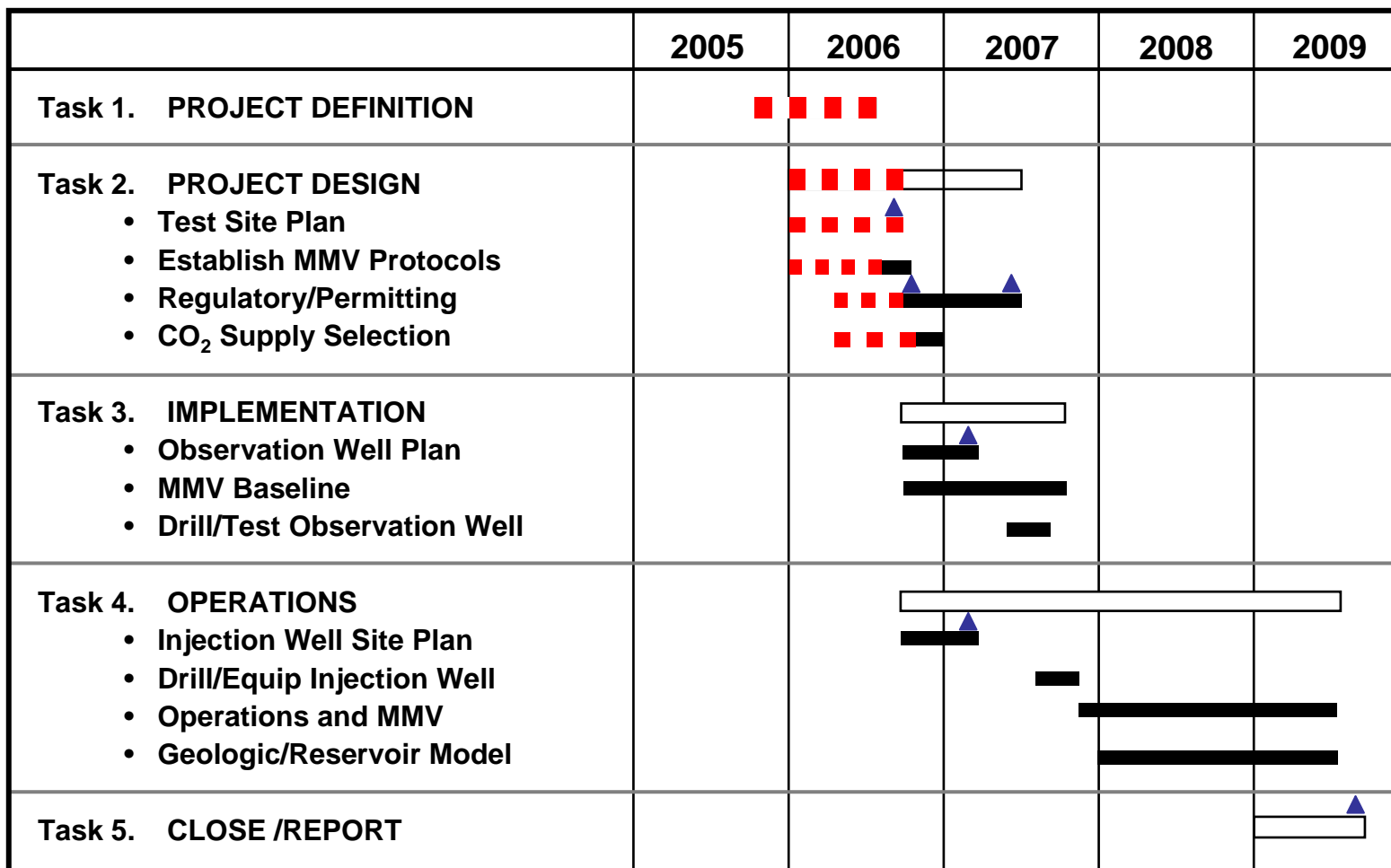
Permitting, NEPA, Abandonment

- **Permitting.** Demonstration Partner taking the lead in interactions with MDEQ/MOGB with respect to well permitting. A Class V well permit is anticipated and a joint visit to the MDEQ has been completed to introduce the detailed project plan and review existing applications on file. Preparation of permit application underway.
- **NEPA Evaluation.** A NEPA environmental questionnaire was prepared and submitted to DOE Aug 31, 2006. Awaiting DOE approval.
- **Financial Assurance Report.** An annual report would need to be filed by the Site Partner showing financial ability to plug and abandon (if required) the two wells. Currently, no intentions to plug wells after demo complete.

Public Education/ Outreach and Media Coverage

- The Demonstration Partner is directing all local public outreach and external communications.
- The Demonstration Partner will review all DOE media regarding the Saline Reservoir CO₂ Injection Project.
- The project will draw on other saline reservoir CO₂ injection pilots for media and public acceptance experience (e.g., BEG/Texas Frio and AEP/Battelle Mountaineer).
- The project will draw on DOE Regional Partnerships working group for supporting public outreach materials.

Proposed Project Schedule



▲ Key Milestones